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TITLE OF INVENTION

METHOD OF PERFORMING A PANORAMIC DEMONSTRATION
OF LIQUID CRYSTAL PANEL IMAGE SIMULATION IN VIEW
OF OBSERVER'S VIEWING ANGLE

FIELD OF THE INVENTION

The present invention relates to a method for performing a liquid crystal panel image simulation capable of predicting color, brightness, and contrast characteristics of an output image in view of a viewing angle of an observer who views a liquid crystal panel, and displaying the result of the image simulation.

More particularly, the present invention relates to a method for performing an image simulation in view of a viewing angle, and displaying the result of the image simulation.

With the increasing development of multimedia technologies, more people are using a liquid crystal displays (LCDs) which can be made small in size and light in weight such that they are applicable to notebook computers, personal digital assistants (PDAs), and hand-held phones, etc. However, the LCDs have different color implementation characteristics according to

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viewing angles, such that they have a
disadvantage in that a single image is
differently viewed by a user's eye according to
viewing angles. In order to solve the above-
mentioned problem, many developers have
conducted intensive research into a method for
improving image output characteristics varying
with a viewing angle.

In order to improve the image output
characteristics varying with the viewing angle
of the LCD, there have been widely used a
variety of simulation software programs which
calculate electric/optical characteristics of
the LCD using a numerical analysis method, and
predict a final output image of the LCD on the
basis of the calculated result.

FIG. 1 is a conceptual diagram
illustrating an image output method implemented
by conventional LCD simulation software.
Referring to Fig. 1, the conventional LCD
display simulation software 10 acquires
simulation result images 31 and 32 associated
with individual viewing angles of an input image
20, and displays the acquired simulation result
images 31 and 32 using an image result output
module.

In the meantime, an LCD image viewed

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with the naked eye of a user is determined to be
an image based on a new coordinate system (i.e.,
an eye coordinate system) on the basis of an eye
position (i.e., a view point) of an observer who
views an object, instead of an image based on a
three-dimensional world coordinate system
including x, y, and z axes. Moreover, there is
no change in coordinate information contained in
a world coordinate system associated with a
screen, but the other coordinate information on
the eye coordinate system varies with an
observer's viewing angle. Therefore, although
the LCD is fixed to a single position, the
observer views different images according to the
direction of his or her viewing angle.

Therefore, when the user views a
simulation result image, the above-mentioned
conventional image output method does not
consider variation in shape according to the
observer's viewing angle, and displays only an
image formed by LCD image implementation
characteristics varying with the variation in
viewing angle.

FIG. 2 shows a difference between an
image of the conventional image output scheme
and the other image in which an eye-coordinate
variation caused by the viewing angle is

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considered. Referring to Fig. 2, if the
observer views the LCD at a viewing angle (0,45),
an LCD image viewed with the naked eye of the
observer is determined to be an upper image 41
in which perspective is considered. However,
the conventional image output scheme has a
disadvantage in that it displays only an image
formed by LCD image implementation
characteristics in which a perspective variation
based on the observer's viewing angle is not
considered as shown in a lower image 42. The
observer must view a current image after
recognizing numerical viewing angle information
of the current image, resulting in greater
inconvenience of use.

In the case where the observer views
simulation images based on viewing angles of not
only the LCD but also other displays which must
analyze viewing angle characteristics, the
above-mentioned problems commonly occur in the
above-mentioned LCD and other displays.

SUMMART OF THE INVENTION

Accordingly, it is an object of the
present invention to provide a method for
performing an image simulation according to an

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observer's viewing angle, and providing the result of the image simulation in which the viewing angle information of the observer is considered.

It is another object of the present invention to provide a method for outputting an image simulation result such that an observer can conveniently analyze image implementation characteristics varying with a viewing angle of the observer.

In accordance with the present invention, the above and other objects can be accomplished by the provision of a method for displaying an image simulation result comprising the steps of: a) receiving information associated with a viewing angle of an observer; b) generating viewing transformation information using the viewing angle information; c) reading simulation image data to be displayed on a screen on the basis of the viewing angle; and d) projecting the read image on a projection plane perpendicular to the viewing angle, and performing a mapping process of the image on the projection plane.

BRIEF DESCRIPTION OF THE DRAWINGS

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Further feature of the present invention will become apparent from a description of a method for performing a panoramic demonstration of a liquid crystal panel image simulation according to observer's viewing angle taken in conjunction with the accompanying drawings of the preferred embodiment of the invention, which, however, should not be taken to be limitative to the invention, but are for explanation and understanding only.

In the drawing:

FIG. 1 is a conceptual diagram illustrating an image output scheme for providing an LCD image simulation result according to the conventional art;

FIG. 2 shows a difference between an image formed by a conventional image output scheme and the other image in which an eye-coordinate variation caused by the direction of the observer's viewing angle is considered;

FIG. 3 is a flow chart illustrating a method for displaying an image simulation result according to the present invention;

FIG. 4 exemplarily shows viewing-angle direction information and viewing transformation information according to an observer's viewing angle according to the present invention;

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FIG. 5 shows an example in which coordinate information on an eye coordinate system is projected on a projection plane according to the present invention;

FIGS. 6~8 show methods for entering viewing angle information according to the present invention; and

FIG. 9 shows a plurality of mapping-image output examples according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT
OF THE INVENTION

A method for outputting an image simulation result according to the present invention will be explained in detail with reference to FIGS. 3~9.

FIG. 3 is a flow chart illustrating a method for displaying an image simulation result according to the present invention. Referring to FIG. 3, a method for displaying an image simulation result according to the present invention receives information of a viewing angle desired by an observer at step S110, generates viewing transformation information associated with the received viewing angle using

the received viewing angle information at step
S120. Subsequently, the above-mentioned method
performs image calculation corresponding to a
viewing angle of the observer or reads pre-
calculated image data at step S130. An image to
be displayed is projected on a plane
perpendicular to the observer's viewing angle,
and is mapped to the plane at step S140. And,
the mapped image is displayed at step S150. It
is determined whether the observer enters an
input signal associated with another viewing-
angle direction at step S160. If the observer
enters another viewing angle information, a
plurality of steps from step S110 in which
viewing transformation information associated
with the entered viewing angle information is
generated, to step S160 in which it is
determined whether yet another viewing angle
information is entered, are repeated.

In accordance with a preferred
embodiment of the present invention, step S120
during which viewing transformation information
associated with a viewing angle upon receiving
viewing angle information is generated, step
S140 during which a calculated image to be
displayed on a screen is projected on and is
mapped to a plane perpendicular to the

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observer's viewing angle in light of an
observer's viewing angle, and step S150 during
which the mapped image is displayed may use
functions provided from open-source graphics
libraries such as OpenGL and MESA, etc.

Viewing-angle information or viewing-
angle direction information according to the
present invention is indicative of a view-point
coordinate for use in one or more world
coordinate systems. Also, the viewing
transformation information is indicative of
information for converting a coordinate for use
in a world coordinate system into a coordinate
for use in an eye coordinate system.

FIG. 4 exemplarily shows viewing-angle
direction information and viewing transformation
information according to an observer's viewing
angle according to the present invention.
Referring to FIG. 4, the LCD screen 200 is
positioned on a $XwYw$ plane contained in a world
coordinate system including $Xw, Yw,$ and Zw axes. An
origin (O, 250) of the world coordinate system
is positioned at the center of the LCD. In this
case, the viewing-angle information is
indicative of a spherical coordinate (ρ, θ, ϕ) or
a rectangular coordinate (X_E, Y_E, Z_E) in
association with a view point (E,260) displayed

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on the world coordinate system. In the
spherical coordinate, ρ is indicative of a
distance from the origin 0(250) of the world
coordinate system to a view point E(260), θ is
indicative of an angle formed between the Xw
axis and a segment passing through a point
E'(260) projected on the $XwYw$ plane and the
origin 0(250), and ϕ is indicative of an angle
formed between the Zw axis and a vector from the
origin 0(250) to the view point E(260).

In the meantime, the eye coordinate
system includes $Xe, Ye,$ and Ze axes, and uses the
view point E(260) as the origin. Also, the Ze
axis is arranged in parallel to a vector from
the view point E(260) to the origin (0) of the
world coordinate system, and the $XeYe$ plane is
arranged in perpendicular to the Ze axis.

In this case, a predetermined point
(x_E, y_E, z_E) on the world coordinate system is
converted into a point (x_e, y_e, z_e) by a viewing-
transformation matrix shown in the following
equation 1. The viewing-transformation
information may be indicative of individual
components of the viewing-transformation matrix.

[Equation 1]

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$$\begin{bmatrix} x_e \\ y_e \\ z_e \\ 1 \end{bmatrix} = \begin{bmatrix} -\sin\theta & -\cos\phi\sin\theta & -\sin\phi\cos\theta & 0 \\ \cos\theta & -\cos\phi\sin\phi & -\sin\phi\sin\theta & 0 \\ 0 & \sin\phi & \cos\phi & 0 \\ 0 & 0 & \rho & 1 \end{bmatrix} \begin{bmatrix} x_E \\ y_E \\ z_E \\ 1 \end{bmatrix}$$

FIG. 5 shows an example in which coordinate information on an eye coordinate system is projected on a projection plane according to the present invention. Referring to Fig. 5, provided that a projection plane 300 is spaced apart from the view point E(260) by a vertical distance d(301), a horizontal width 302 of the projection plane is determined to be a value of 2W, and a vertical width 303 of the projection plane is determined to be a value of 2L, a coordinate on the eye coordinate system is determined to be coordinate information (X,Y) on the $XsYs$ projection plane including Xs and Ys axes, and the coordinate information (X,Y) can be represented by the following equations 2 and 3:

[Equation 2]

$$X = d\frac{x_e}{z_e} + W$$

[Equation 3]

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$$Y = d\frac{y_e}{z_e} + L$$

Therefore, according to the present
invention, an observer can allow an LCD image
400 varying with his or her viewing angle
information to be displayed. In other words,
image data differently calculated according to
viewing angle information or pre-calculated
image data is read out and is mapped to an LCD
image in which perspective is considered,
resulting in the implementation of a more
realistic image varying with a viewing angle.

FIGS. 6~8 show methods for entering
viewing angle information according to the
present invention. As shown in FIG. 6, a user
enters a spherical coordinate or a rectangular
coordinate in association with one or more view
points using a dialogue box 510 implemented by
Windows program, such that the user can enter or
correct viewing angle information. The user can
also select pre-defined viewing angle
information instead of the desired viewing angle
information. As shown in FIG. 7, the user may
determine the position of the view point on an
additional coordinate system 520 using a mouse
or keyboard, and may enter or correct the

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position of the view point. As shown in FIG. 8,
the user may click on or drag a desired
coordinate on the projection plane 300 on which
a mapped image is displayed, using a mouse, such
that the user may enter or correct viewing angle
information in real time, and at the same time
may control the mapped image to be displayed.

In accordance with a preferred
embodiment of the present invention, either one
of information associated with an output image
and viewing angle information 610 and their
combination can be displayed on the projection
plane 300 at the same time.

FIG. 9 shows a plurality of mapping-
image output examples according to the present
invention. Referring to FIG. 7, a plurality of
divided projection planes are displayed at the
same time, such that mapping result images
associated with different viewing angles are
shown at the same time.

As apparent from the above description,
a method for displaying a simulation result
image according to the present invention allows
an image simulation result to be displayed in
the form of an image viewed with the naked eye
of an observer who views an LCD screen, such
that it can analyze implementation

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characteristics of a more realistic image. Also, the present invention allows the observer to enter a variety of viewing angles, and provides the observer with a variety of resultant images, and allows the observer to conveniently analyze image characteristics varying with a viewing angle.

Although the invention has been illustrated and described with respect to exemplary embodiments thereof, it should be understood by those skilled in the art that various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the present invention.

Therefore, the present invention should not be understood as limited to the specific embodiment set forth above but to include all possible embodiments which can be embodies within a scope encompassed and equivalents thereof with respect to the feature set forth in the appended claims.